caught a long series of them. It seems clear they were not immigrants from Durban, but what caused their appearance in such unusual numbers it is difficult to understand. I may mention that in the last few years Mr. Ball has caught two *E. wahlbergi* but has never seen *dominicanus*. While there, I saw six females of *P. cenea*, two of each of the three forms."

31. Warning Colours and Mimicry (almost wholly Müllerian) in South African Coleoptera. (G. A. K. M., E. B. P.)

[In the groups described below, Coleoptera play a dominant part, either making up the whole or, except in the case of the Mutilloid group, acting as models for other insects. In this one exception the chief interest centres in the Coleoptera, and therefore the group is included here. A certain number of mimetic Coleoptera will be mentioned elsewhere in other groups which have collected round various types of Hymenopterous models.

In the present section the extraordinary predominance of Müllerian associations in South African Coleoptera stands out as the most prominent conclusion.—E. B. P.]

A. *Peculiar Warning Patterns and Directive Marks in Carabidæ and Cicindelidæ.* (E. B. P., G. A. K. M.)

Some of the warning patterns of the large *Carabidæ* of the genus *Anthia* are very remarkable and effective, and their development and relationship in the different species extremely interesting.

Six illustrative examples are figured on Plate XVII. In Fig. 21 we see the ancestral appearance, the uniform black of so many large Carabids, in *Anthia massilicata*. Mr. Marshall's account of the habits of the South African members of the genus, printed on page 510, shows that such a beetle is highly conspicuous. It is no doubt an advantage, however, to gain easily-recognizable distinctive marks on the black ground of the exposed dorsal surface, and we find that the species of *Anthia* do, as a rule, possess two or more white patches upon some part of this area. The pair of elongated thoracic white patches, in *A. petersi* (Fig. 22), are borne upon the sides of a thorax which is very like that of *massilicata*, while in *A. thoracica* (Fig. 23) this part of the body is greatly widened and the white patches

become a broad oval in shape. A pair of white spots (as well as a white line towards the outer border of the posterior half of the elytra) has also arisen on the anterior part of the elytra in *A. omoplata*, var. *mellyi* (Fig. 26), and it is of deep interest to note that these spots at a little distance or when the insect is moving would resemble the entirely different thoracic spots of *thoracica* far more closely than these latter resemble the entirely homologous spots of *petersi*. The comparison of Fig. 23 with 22 and then with 26 will bear out this conclusion. Perhaps one reason for the development of the remarkable structures in which the spots are situated in *thoracica* (they are placed in the concavities of special lateral outgrowths of the thorax) may be in order to favour the synaposematic approach to an arrangement like that of *mellyi;* for by this means it is possible for the spots to attain approximately the same size and shape, and at the same time to retain an interval between them which corresponds to that obtaining in the very different position upon the elytra. The concavities exist however in a much smaller form in *A. maxillosa*, and the white markings in them are inconspicuous.

In *A. nimrod* from West Africa (Fig. 25) we see a further development of the *mellyi* pattern in the appearance of another pair of spots on the posterior region of the elytra, while in *A. sex-guttata*, from India (Fig. 24), this appearance is combined with the two spots of *thoracica*, thus building up a warning pattern of remarkable simplicity and effectiveness, being an almost exact negative of the six of dominoes. The success of the aposeme is much enhanced by the approximate equality of the shorter intervals between the spots of each pair, and the longer ones between the spots of one pair and the corresponding spots of the next. The great breadth of the thorax permits this symmetry in one direction without the development of outgrowths like those of *thoracica*, while symmetry in the other direction has been rendered possible because the middle pair of spots occupies a more posterior position on the elytra than does the corresponding pair of *nimrod* or *mellyi*. It will be seen by a glance at Figs. 23 to 25 that the addition of the spots of Fig. 23 to the thorax of Fig. 25 would produce a very inferior warning pattern as compared with that of *sex-guttata* (Fig. 24).

Mr. Marshall gives the following account (1902) of the habits of these formidable beetles :—

"The warning character of the large spots and stripes of the Anthias (Plate XVII, figs. 22–26) is well borne out by the appearance of these insects in their natural haunts. They are purely terrestrial in their habits, and prefer open, treeless country, where owing to their large size and striking coloration they are very conspicuous objects. When alarmed they adopt a very characteristic warning attitude, raising themselves high on their legs, walking in a quick jerky manner and often twisting sharply from side to side: but, as in the case of other aposematic insects, when they find these demonstrations are of no avail they endeavour to make good their escape and are then capable of running at a very fair pace. Their acid secretion is very powerful, and causes a strong stinging sensation when it touches the skin of the face or the more tender parts of the hands, and as it can be projected to a distance of some four or five feet, the insect would have to be captured with considerable caution even by an enemy which might be aware of its powers. The liquid is always ejected upwards, and the insects seem capable of controlling its direction to a limited extent. A very similar warning attitude is observable in the huge Cicindelids of the genus *Mantichora*, at least I have seen it in *M. herculeana*. The habits of this insect are very similar to those of *Anthia*, but it cannot project its protective secretion, which merely exudes when it is handled; the liquid also is not acid as in *Anthia*, but possesses a strong smell."

Mr. Marshall brings forward the very probable hypothesis that the posterior white spot or spots of the small and medium-sized *Carabidæ* are directive. The fact that they form an important element in the Mutilloid appearance of these Coleoptera is no objection whatever to this hypothesis, which is explained in detail below; for it is probable that the posterior white spots of the female *Mutillidæ* may have a similar function, directing attention to the sting. Mr. Marshall states (1902) that the abdomen is the most conspicuous part of a Mutillid (see p. 512).

"Among the diurnal *Carabidæ* in South Africa the frequent occurrence of a conspicuous white spot at the apex of the elytra is very noticeable, and there is good ground for believing that this spot is of a directive character. Unlike such insects as *Cantharidæ*, *Lycidæ*, etc., the *Carabidæ* do not appear to possess any general distastefulness, but depend for protection solely upon their

power of squirting a strongly acid liquid from behind. In the case of the largest species, such as *Anthia*, the great strength and large quantity of this liquid render it a very efficient protection; but in the smaller species my experiments and observations lead me to suppose that this is not the case, but that the utility of the secretion lies rather in the fact that it enables the insects momentarily to disconcert their enemies, and this, owing to their great activity, gives them an opportunity to escape. Under these circumstances it is evidently of importance that an attack from an enemy should be directed to the anal portion of the body in order to ensure its receiving the discharge. The anal white patch is especially noticeable in such genera as *Polyhirma* (*semisuturata*, *bennettii* [see Appendix, pp. 547, 548], *notata*, *rutata*, *macilenta*, etc.) and *Piezia* (*marshalli* and *mashuna*); it also occurs in the Cicindelid *Myrmecoptera polyhirmoides* which consorts with many of the above species. It is probable that the two white or yellow spots which are found in so many *Carabidæ* and *Cicindelidæ* (see Plate XVII, figs. 7–11, 14–19) towards the apex of the elytra have also a similar significance, that of the *Cicindelidæ* being of course mimetic (of *Mutillidæ* and *Carabidæ*)."

B. *Mutilloid Colcoptera: Cleridæ, Carabidæ, and Cicindelidæ: Primary and Secondary Synaposematic and Pseudaposematic Associations.* (E. B. P.)

When forwarding the following mimics of *Mutillidæ*, Mr. Marshall also sent a record of habits:—

"*Salisbury, Jan.* 8, 1899.—The Mutilloid type is not uncommon among *Carabidæ*, *Eccoptoptera cupricollis* being a beautiful instance of mimicry. But the markings are most developed among the *Cleridæ*, of which I have no less than twelve species all exhibiting the Mutilloid marking more or less distinctly; I expect they will be found to be parasitic on *Mutillidæ*. I have also caught a little spider which is an excellent Mutilloid mimic."

This species of Mutilloid spider and another sent later have been described by the Rev. O. Pickard-Cambridge, F.R.S., as *Prosthesima albomaculata* and *Titus lugens*. (Proc. Zool. Soc. Lond., 1901, p. 11, figs. 2, 3, Plate V.)

"*Salisbury, Feb.* 12, 1899.—The Mutilloid group is interesting though not so satisfactory from a cabinet point

of view, the resemblance being much less marked than in the field, except perhaps *Eccoptoptera* which is a splendid case, and it has caused me to hesitate more than once before venturing to handle it. At the present time I would not venture to express an opinion as to the use or significance of the colours in this group. The *Mutillidæ* of course are armed with a powerful sting, which however they are slow to use, and besides they are very hard; the red prothorax is by no means conspicuous when they are running on the ground, the abdomen being the part that catches the eye, and when hard pressed this is elevated in the air evidently as a warning. I have noticed that it is very difficult to distinguish the pattern while the insect is running, the general impression being merely that of a black body with white spots. The same applies to the *Cicindelidæ* and *Carabidæ*, which are all fast runners and most of them very difficult to distinguish *inter se* in the field at first sight. The exact resemblance of *Graphipterus antiokanus* to *Piezia selousi* is marred by the shrinkage in the former of the pygidium, which bears two white patches. *Atractonota*, despite its markings, very much resembles one of our larger black ants, especially in its manner of running. A good many other species (especially of *Cleridæ*) might also be included in the group."

The Mutilloid group of Coleoptera from Salisbury may be arranged together with their models as follows, the plan being that adopted in Plate XVII, figs. 1–12 and 14–19:—

MUTILLIDÆ					
Mutilla purpurata ♂ Fig. 1.	M. tettensis ♀ Fig. 2.	M. cepheus ♀ Fig. 3.	M. leucopyga? ♀ Fig. 4 (Nov. 1898—Jan. 1899).	M. syconax ♀ Fig. 5.	M. horrida ♀ Fig. 6. (Nov. 1898—Jan. 1899).
CARABIDÆ					CLERIDÆ
Atractonota mulsanti Fig. 7.	Atractonota mulsanti Fig. 8.	Polyhirmaænigma Fig. 9.	Polyhirmaænigma Fig. 10 (Nov. 1898—Jan. 1899).	Eccoptoptera cupricollis Fig. 11.	Graptoclerus, sp. Fig. 12.
CARABIDÆ			CICINDELIDÆ		
Graphipterus antiokanus Fig. 14 (Nov. 1898—Jan. 1899).	Piezia selousi Fig. 15.	Polyhirma bilunata, Boh. Fig. 16. (Nov. 1898—Jan. 1899).	Myrmecoptera marshalli Fig. 17.	Myrmecoptera invicta Fig. 18.	Myrmecoptera bilunata Fig. 19.

All were captured at Salisbury, in Nov. 1898, with the exception of those specially noted as taken between Nov. 1898 and Jan. 1899.

Other species are not included in the Plate for want of space. Thus *Piezia marshalli* has a single median white spot, of which half is on one elytron and half on the other, in place of the posterior well-separated pair of spots on *P. sclousi;* and there are other species, outlying members of the group under discussion, in which the Mutilloid appearance becomes less marked, while in *Polyhirma semisuturata* it fades away altogether, although this intensely black beetle, with its white dorsal line anteriorly and white patch posteriorly, seems to be very conspicuous. The appearance of the group and the relation to the outlying species suggest a strong and very complex Müllerian association. The large *Carabidæ* of the genus *Anthia* are either entirely black or possess a peculiar synaposematic appearance, described on pp. 508–510, and figured on Plate XVII, figs. 22 to 26. The smaller *Carabidæ*, depending upon a less development of the same defence —the power of discharging a strong acid secretion— have gained an appearance, due, like that common in *Anthia*, to white markings on a black ground, but arranged so as to suggest more or less strongly the likeness of a *Mutilla*. In a single species, as Mr. Marshall points out, the resemblance is extraordinarily exact (Plate XVII, fig. 11). This may be on account of habits and a mode of life which render the likeness especially beneficial. The smallest *Carabidæ*, the *Atractonota* and *Polyhirma ænigma* (Plate XVII, figs. 7–10), in shape resemble large ants, and Mr. Marshall states above that the movements of the former aid in producing this effect. On the other hand, their white spots appear to be certainly Mutilloid or perhaps rather to resemble the Mutilloid white spots of the other unant-like *Carabidæ*. Nothing is more characteristic of a Müllerian (synaposematic) group than the complexity of likeness which is thus revealed, and yet in the light of the great hypothesis which we owe to Fritz Müller it is not difficult to understand the general principles which account for its existence.

The *Carabidæ* are a powerful, specially defended group, and it is of advantage to be recognized as belonging to the group, even though it is no doubt of still greater advantage to be mistaken, as may happen at a distance,

or on a superficial view, or during rapid movement, for the still more formidable *Mutillidæ* and ants. Hence, although the smaller species of this group resemble the latter, and the larger the former, markings are nevertheless retained which serve to connect these Coleoptera together, and enable the experience gained in an attack on one of them to be of service in preventing the waste of life in many other species. For the same reason we can understand another curious inter-relationship, viz. that there is a superficial resemblance between different genera of *Carabidæ* and between *Cicindelidæ* and *Carabidæ*. Running through, but not concealing the resemblance to the Hymenoptera, is a resemblance between the Coleopterous mimics themselves. Thus there is the likeness described by Mr. Marshall on p. 512, between *Graphipterus antiokanus* and *Piezia sclousi* (compare Plate XVII, figs. 14 and 15), while the remarkable likeness of the *Cicindelidæ* to the *Carabidæ* will be at once appreciated when Figs. 17, 18 and 19 are compared with 15 and 16. The same explanation is doubtless valid. The *Cicindelidæ* are less powerful than the *Carabidæ*, but many of them emit a peculiar scent, and the genus *Tricondyla* is closely mimicked in Borneo by the Locustid *Condylodera tricondyloides*. We can well understand that it is to the advantage of *Cicindelidæ* to be one with another and more powerful set of Coleoptera, even though it may be a further and probably greater advantage to resemble the *Mutillidæ*, a resemblance which is also involved in the appearance they have gained. If this explanation be sound we shall expect also to find examples of the same kind of likeness between *Cicindelidæ* and *Carabidæ* which do not resemble these Hymenoptera. Plate XVII shows that this is undoubtedly a fact, for the all-black *Polyhirma boucardi* (Fig. 13) is seen to be strongly resembled by a Cicindelid, *Myrmecoptera polyhirmoides*, var. *mashuna* (Fig. 20), belonging to the same genus as the three white-marked species figured in the same Plate.

The *Cleridæ* everywhere tend to resemble *Mutillidæ*, but they also resemble *Cantharidæ*, and more rarely *Lycidæ* and even *Coccinellidæ*, while one genus is beautifully mimicked by a Longicorn in Borneo. The first-mentioned likeness is probably a marked example of synaposematic colouring, and I should expect that the character of the original structure and warning pattern,

rather than the parasitism which Mr. Marshall suggests, rendered resemblance to *Mutillidæ* above all other specially-defended insects particularly feasible for these Coleoptera. A good example of such mimicry is seen in Plate XVII, fig. 12, representing *Graptoclerus*, sp.

I believe that the principles discovered by F. A. Dixey, which are here employed to explain the curiously complex inter-relationships of Mr. Marshall's Mutilloid group, will hereafter be found to have an important bearing upon many superficial resemblances of mimicry and common warning colours in all countries, and in many orders of insects and probably other animals.

The double (or treble, etc.) resemblances which may be perceived one underlying the other in the appearance of a single form may be conveniently spoken of as Primary, Secondary, Tertiary, etc., Common Warning Colours (Proto-, Deutero-, Tritosynaposematic Resemblance), or as Primary, Secondary, Tertiary, etc., Mimicry (Proto-, Deutero-, Tritopseudaposematic Resemblance). Thus the resemblance of the *Atractonota* to an ant, or of *Myrmecoptera* to a Mutillid is Protosynaposematic, while their resemblance to the Carabid genera *Polyhirma, Piezia*, etc., is deutero-synaposematic. On the other hand, the resemblance of the black *Myrmecoptera* to *Polyhirma boucardi* is proto-synaposematic, or rather, synaposematic, since there appears to be no other underlying or overlying resemblance in this case.

Many examples of this kind will be found in the section on Mimicry in Lepidoptera; see especially pp. 470, 471, 485–487.

I must here again refer to Dr. F. A. Dixey's important memoirs, alluded to in greater detail on p. 502, as containing the first account and interpretation of the extremely complex inter-relationships which may exist in Müllerian associations. The principles which he laid down are here found to supply the interpretation of many puzzling and subtle relationships, not only among Lepidoptera, but also in other Orders in which the phenomena of mimicry, warning colours, etc., have been far less fully investigated.

C. *Lycidæ as Models for other Coleoptera and Insects of many Orders.* (G. A. K. M.)

[The splendid and complex convergent group, represented on Plate XVIII, figs. 1–52, is by far the most

complete illustration hitherto known of the power of mimicry to attract forms of all kinds irrespective of affinity. It is of the deepest interest to observe that the association is almost entirely Müllerian (synaposematic). The following passages are quoted from letters written by Mr. Marshall about the time when the first consignments were sent; but the group became very much larger when the additions of later consignments were included.—E. B. P.]

Salisbury, Jan. 8, 1899.—The two most prominent types of colour among mimetic Coleoptera are what I call the Lycoid and Mutilloid types. Of the former I have put aside for you a series comprising fifteen species, including several species of *Lycus*, three species of Longicorns, a Reduviid bug, a fly, a wasp, an Arctiid moth, a *Mylabris*, a *Hyperacantha*, etc., and I shall be able to add more in all probability.

The Lycoid Arctiid moth is a day-flyer, but the deceptive resemblance is not good on the wing, being best shown when the moth sits, as is its wont, on the ends of grass-stems, etc., after the manner of a *Lycus;* it is perhaps even more like *Prionoccrus dimidiatus*, a Lycoid unpalatable Malacoderm which has a similar habit.

Salisbury, Feb. 12, 1899.—The six species of *Lycus*, the *Prionoccrus*, *Diacantha*, *Zonitis*, *Mylabris*, and *Eletica*, I proved by experiment to be distasteful to baboons and a kestrel. The Zygænid I presume to be so likewise, as it emits a strong smell; the *Telephorus* will also probably prove to be unpalatable. The four species of wasps have all got very effective stings; thus the only unprotected insects are the fly, which is an admirable mimic of one of the wasps, and the three Longicorns, though I am not quite certain about *Philagethes*. As to the *Reduvius* I do not know what to say, there are certainly some very remarkable cases of mimicry in this family. * * * *
In flight the Zygænid [*Neurosymploca*, Fig. 52] is aided by its very brilliant hind-wings, and the Hymenoptera have a flight very different from, and far swifter than, that of *Lycus*.

[A complete list of the species arranged in their respective families is given below. Large as the group is it could certainly be made much larger, especially if the whole of South Africa were put under contribution. Thus an obvious addition to the Longicorn mimics is *Dyenmo-*

nus apicalis, which Mr. Marshall has not yet taken in Mashonaland.—E. B. P.]

GROUP WITH LYCOID MARKINGS (Plate XVIII, figs. 1–52).

COLEOPTERA	*Copridæ*	Aphodius holubi (fig. 18).
	Malacodermata	Lycus (Merolycus) rostratus (figs. 1, 2). Lycus (Acantholycus) constrictus (fig. 3). Lycus ampliatus (figs. 4, 5). Lycus (Lopholycus) zonatus (fig. 6). Lycus (Lopholycus) haagi (figs. 7, 8). Lycus (Chlamidolycus) subtrabeatus (figs. 9, 10). Lycocerus mimicus (figs. 11, 12).
	Melyridæ	Prionocerus dimidiatus (fig. 13).
	Phytophaga	Pœcilomorpha fasciaticollis (fig. 14); Diacantha conifera (figs. 16, 17). Peploptera zambesiana (fig. 15).
	Lagriidæ	Entrapela sp. (fig. 19).
	Cantharidæ	Eletica rufa (figs. 20, 21); Mylabris palliata (fig. 22); Zonitis sp. (fig. 23).
	Longicornia	Amphidesmus analis (fig. 25); Philagathes lætus (figs. 26, 27). Nitocris sp. (fig. 28); N. similis (fig. 30); N. ?nigricornis (fig. 29). Blepisanis haroldi (fig. 24).
HYMENOPTERA	*Braconidæ*	Phanomeris sp. (figs. 44, 45); Iphiaulax bicolor (fig. 46); Bracon luctuosus (fig. 47); Bracon ?luctuosus (fig. 48).
	Pompilidæ	Pompilus morosus (fig. 36); P. capensis (fig. 37); P. diversus (fig. 38); P. vindex (fig. 39).
	Crabronidæ	Cerceris orientalis, var. (fig. 40).
	Larridæ	Notogonia crœsus (fig. 41).
	Eumenidæ	Rhynchium radiale (fig. 42); R. rubens (fig. 43).
HEMIPTERA	*Pyrrhocoridæ*	Serinetha mutilata (fig. 33).
	Lygæidæ	Lygæus furcatus (fig. 34); Oncopeltus famelicus, var. jucundus (fig. 35).
	Reduviidæ	Vitumnus miniatus (fig. 32); V. cinnabarinus (fig. 31).
LEPIDOPTERA	*Arctiidæ*	Ilema elegans (fig. 50).
	Zygænidæ	Neurosymploca ochreipennis (fig. 52); Zygænid (genus ?) (fig. 51).
DIPTERA	*Asilidæ*	Xiphocerus cruciger (fig. 49).

In the above group the beetles of the genus *Lycus* undoubtedly constitute the dominant factor towards which the other insects have converged with more or less exactness. The members of this genus are very numerous throughout S.E. Africa both in species and in individuals. They are most conspicuous insects, and the majority of them occur on flowers, though a few species are more often

to be found on the heads of grasses. In habits they are very sluggish and have a slow heavy flight; when handled they usually emit from their limbs a very strong-smelling white liquid, and they frequently feign death. The Melyrid *Prionoccrus* has somewhat similar characteristics, but is found only feeding on grass seeds. Among the Phytophaga it is possible that the *Pœcilomorpha* is a Batesian mimic, for the species of this genus are nearly all more or less scarce, and moreover exhibit marked mimetic tendencies in very different directions. The *Diacantha*, to which *D. dimidiata* might also have been added, is a very plentiful insect with a nauseous smell; it causes much damage to garden plants such as cucumbers and pumpkins. The *Peploptera* is likewise abundant, frequenting acacias. All the species of Lagriadæ and Cantharidæ mentioned are flower-feeders, and are certainly protected by distasteful qualities. The significance of the colouring in the Longicorns is still a matter of doubt, as I have obtained no experimental evidence with regard to them; probably most of them are pseudaposematic, but *Philagathes* may be a Müllerian mimic. Of the Hymenoptera the quick-flying *Notogonia* is the only scarce species with us; the other Aculeates all visit flowers more or less commonly. The Braconids are slow and very conspicuous fliers, being evidently protected by their very strong smell. The species of Hemiptera also occur commonly on low plants and bushes; the position of the Reduviids is not quite certain, as experimental proofs are lacking. The Asilid fly appears to be a very rare species and is doubtless a Batesian mimic.

D. *Müllerian* (*Synaposematic*) *Groups in South African Coleoptera.* (G. A. K. M.)

a. Cantharid Group (Represented on Plate XIX).

Coleoptera	*Cantharidæ*	Mylabris dicincta (fig. 1); M. tettensis (figs. 2–3); M. tricolor (fig. 4); M. oculata (figs. 5, 6, 13); M. holosericea (fig. 9); Actenodia chrysomelina (figs. 7, 8, 11); Decatoma lunata (figs. 10, 12).
	Longicornia	Cymatura bifasciata (fig. 14); Ceroplesis caffer (fig. 15); Anubis mellyi (fig. 16).
	Phytophaga	Clythra wahlbergi (fig. 20).
Hemiptera	*Lygæidæ*	Oncopeltus famelicus (fig. 17).

The same species is sometimes repeated two or even three times in the Plate in order to show common variations in the pattern.

All the species of Cantharidæ in this group are abundant in Salisbury, some of them occurring in such numbers as to form a serious pest in the local flower-gardens. All those mentioned feed on flowers exclusively, except *M. holosericea* which seems to be more attached to grasses. In every case they emit a quantity of vesicating yellow juice from the antennæ and joints of the legs when handled, and also eject a liquid from their mouths; their flight is heavy and noisy, and they are most conspicuous insects in every way. *Ceroplesis caffer* is probably the commonest Longicorn in South Africa, attacking dead wood of almost any description, but particularly frequenting acacias. It has a slow conspicuous flight, and has been proved by experiment to possess distasteful qualities, though I have not noticed that it gives off any smell.

The Longicorn *Cymatura bifasciata* is specially attached to a species of *Lantana*, which grows to a fair-sized bush, and the insects occasionally may be found on it in some numbers. It is certainly a Müllerian mimic, as it has a strong smell, is very sluggish, and feigns death persistently when captured. It was refused with evident dislike by baboons. *Anubis mellyi* does not occur at Salisbury, but is fairly common at Umtali, further east, where it frequents the flowers of low plants. It is a brightly-coloured insect, and emits the strong characteristic smell of the diurnal Cerambycidæ.

β. *Intermediate Group connecting the Cantharid and Coccinelloid Groups* (Represented on Plate XIX).

Coleoptera	*Cantharidæ*	Actenodia chrysomelina (figs. 7, 8, 11).
	Phytophaga	Melitonoma sp. nov. (fig. 18); M. truncatifrons (fig. 19); M. litigiosa (fig. 21); M. epistomalis (fig. 23); Antipus rufus (figs. 22, 25); Clythra lacordairei (fig. 24); Aulacophora festiva (fig. 26); Cryptocephalus 5-plagiatus (fig. 27); C. varioplagiatus (fig. 28); Syagrus marshalli (fig. 29).

This group merges very gradually into the Mylabroid group on one hand, especially in those species where the rows of spots coalesce into transverse bands, and at the

other end of the series it converges to the Coccinelloid type, particularly in the *Cryptocephali*. The association is probably of a purely Müllerian character so far as the species mentioned are concerned. They all have very similar habits, occurring on low plants and flowers, and making no attempt at concealment. *A. festiva* is much more plentiful than the others, and is probably the dominant member of the group.

γ. *Coccinelloid Group* (Represented on Plate XIX).

Coleoptera	*Coccinellidæ*	Epilachna dregei (figs. 40, 41); Chilomenes lunata (fig. 42).
Hemiptera	*Pentatomidæ*	Steganocerus multipunctatus (fig. 39).

I have frequently found all these three species occurring together on the flowers of a *Lantana*, and as they are all common, conspicuous, and strong-smelling insects, the group is undoubtedly synaposematic.

δ. *Group of small pale yellow and red Phytophaga with their Melyrid and Curculionid Mimics.* (E. B. P.)

With respect to a series of nine small brightly-coloured Coleoptera of about the same size (with the exception of *Urodactylus*, ? sp. ♀, which is conspicuously smaller than any of the others), Mr. Marshall wrote that he should be unwilling to hazard an opinion. It appears tolerably clear however that they form a beautiful Müllerian group, including perhaps a single Batesian mimic. All were captured at Salisbury, and, with the two exceptions noted below, in January 1899. The species are arranged below as they are on Plate XIX, where each is represented twice the natural size.

Phytophaga.

Platyxantha bicincta fig. 30.	Gynandrophthalma posticalis [or closely allied, M. Jacoby] (Feb. 1899) fig. 31.	Monolepta vincta [or closely allied, M. Jacoby] fig. 32.
Crioceris coronata, Baly (=balyi, Harold) fig. 33.	Paralepta ornata fig. 34.	Asbecesta ornata fig. 35.

Melyridæ.		Curculionidæ.
Urodactylus, sp. ♂ fig. 36.	Urodactylus, sp. ♀ fig. 37.	Apoderus gentilis (Nov. 1898) fig. 38.

The group consists of pale yellow insects with bright red anterior section, made up by thorax and head, of which the eyes only are black in some of the species, although in others black markings extend over a variable proportion of the cephalic surface. The elytra are crossed transversely by a black band at the base, and another at the junction of the third and posterior fourth of their length. In some species the anterior band, in others the posterior is reduced to two more or less widely-separated spots or patches. In the species of *Criocceris*, the anterior band is represented by four small black spots, two on each elytron. In the *Urodactyli*, the posterior band is represented by a semi-circular black mark with the concavity directed posteriorly on each elytron.

In spite of the variation in detail the species would produce the same effect at a little distance, and there can be no doubt about the interpretation of the whole as a synaposematic combination with the *Curculio* as a doubtful pseudaposematic member. Mr. Marshall states that there are many other species of about the same size which adopt the same warning pattern, including at least four additional species of *Melyridæ*.

Certain members of this group are very abundant and conspicuous in the spring months upon the Mosasa-tree (*Brachystegia* sp.).

E. *Comparison between certain Coleopterous Groups in Borneo and South Africa, with respect to Mimicry, Common Warning Colours, etc.* (G. A. K. M.)

[The following interesting comparison between the phenomena of mimicry and common warning colours in certain Coleopterous groups in Borneo and South Africa respectively, was made upon the receipt of a set of photographs of the material of Mr. Shelford's paper now being published by the Zoological Society.—E. B. P.]

Salisbury, Jan. 11, 1901.—I should be interested to know whether Shelford has proved the *Anthribidæ* to be

distasteful; from my knowledge of our fairly numerous South African species I should be much inclined to doubt it, as their colouring appears to be, without exception, protective, generally resembling bark or lichen; and although there are somewhat similarly-coloured Longicorns which frequent such surroundings, I should certainly class their colours as syncryptic. A somewhat similar criticism suggests itself with regard to the *Brenthidæ*, although I feel diffident in stating it, as the family is so very limited here. I know of only four species in Salisbury, all of which are sub-cortical and nocturnal in their habits, of comparatively rare occurrence, and of dull colouring. On the other hand, I have observed that the great majority of our smaller Lamiids adopt the forward position of the antennæ, which I have always regarded as procryptic, as there can be no doubt that it renders them much less conspicuous than if the antennæ were held out at an angle to the twig on which the insect sits. The procryptic nature of the position is well illustrated in the small and very elongate Longicorns *Hyllisia* and *Hippopsicon*, of which we have a few species, all of which frequent grass-stems in marshy places; they also have the elytra bifurcated, and this seems to be a common occurrence in all very elongate beetles. The Endomychid groups are very interesting. Unfortunately this family is extremely poorly represented here—only some three or four species, though the *Erotylidæ* are fairly numerous. In this latter the pattern with four yellow or reddish blotches on a black ground occurs also with us, and the insects are probably distasteful, judging by the extremely pungent smell emitted by the large *Encaustes*. Curiously enough, just after getting your photographs I found under bark a large Endomychid (new to me) of this pattern, and with it occurred an admirable mimic, a Carabid *Thyreopterus flavosignatus* (Dej.). There is another Carabid *Arsinoë fraterna* (Pér.), also sub-cortical, which mimics it closely, but unfortunately I have no specimens now; I caught only two here six years ago.

F. *Note on Rhynchophora with Procryptic Colouring as Models for Mimicry.* (E. B. P.)

Dr. A. R. Wallace has always thought that the extreme hardness of the mimicked *Curculionidæ* and *Anthribidæ*

is the character which protects them ("Essays on Natural Selection," 1875, p. 94). In answer to a letter in which I drew his attention to Mr. Marshall's record of a large *Curculio* found in the crop of a guinea-fowl (see p. 350), he wrote, Feb. 5, 1901, "The large Malayan *Anthribidæ* are *intensely* hard. The guinea-fowl proves nothing, as these beetles are almost all *arboreal*, and their chief enemies are *smaller* birds. Their protective colours may save them from the *larger* insectivorous birds, their hardness from the smaller." The mimicry of Malayan *Curculionidæ*, *Anthribidæ*, and *Brenthidæ* by Longicorns cannot be doubted. The cases are too numerous and the details of the resemblance too precise to admit of any other explanation. In South Africa, on the other hand, Mr. Marshall shows that only the first group is mimicked, and of this he has sent me a very beautiful example. Experiments are greatly wanted, especially in Borneo, where all three groups abound. In addition to their hardness Mr. Shelford shows that the larger Bornean Curculios are defended by their great strength; they can even cause intense pain to man by clasping the fingers with their legs and digging the proboscis into the flesh. Such defences as hardness and strength depend for their success on the size of enemies; for even hardness could not avail against an enemy large enough to swallow the beetle whole, so that it could be ground down in the gizzard, or the interior slowly extracted by digestive fluids gaining access by the joints and other apertures. Defence by a sting, a nauseous taste or smell, or unwholesome qualities, is effective against enemies of all sizes and all degrees of strength, although failing against occasional specially-adapted foes. It is possible that these considerations may enable us to understand why it is that certain *Rhynchophora* are remarkable among Coleoptera for combining a cryptic colouring with sufficient immunity to render them feasible models for mimicry. The ordinary methods of active defence among vertebrates—the power of biting or pecking, of kicking or tearing with hoofs or claws—together with the passive resistance of a spiny or hard external covering, are almost invariably associated with cryptic colouring and modes of life favouring concealment. The probable explanation is that all such methods of defence must fail before large and important classes of still stronger enemies or foes with cunning sufficient to circumvent the passive

defence. Such enemies are numerous enough and deadly enough to make the increased danger of a conspicuous appearance far greater than any advantage gained by the warning off of smaller and weaker animals. Such a defence as that of the skunk, on the other hand, appeals to enemies of many classes, and is quite independent of strength or size. Here and there special animals, probably powerful birds with deficient sense of smell, can endure the defensive odour, and to these the skunk would be an easy prey; but on the whole the increased danger of a conspicuous appearance and slow movements is far more than compensated by the warning off of an immense number of would-be enemies. Cases like that of the skunk are very common among insects, while those of active defence are very rare. Even the passive defence of a spiny or hairy covering is very different from that ordinarily adopted among vertebrates, because in the insect the hairs and spines are themselves a cause of unpalatability, and often of intense irritation, so that they tend to be associated with an aposematic appearance. It is, however, probable that the intensely hard Rhynchophora with a cryptic appearance, and especially the largest and most powerful *Curculionidæ*, are strictly comparable with the large number of vertebrates which also unite the methods of concealment with very efficient modes of active or passive resistance. Certain of the largest *Curculionidæ* possessing red marks on a black ground appear to possess an aposematic appearance, and these may be distasteful, although the conspicuous appearance may only indicate an excessive hardness and thickness of chitin which, coupled with the great size, may be a most efficient defence against a majority of enemies. Mr. Marshall tells me that the largest South African Curculios of the genus *Brachycerus*, such as *B. apterus*, are purely terrestrial, move slowly, and freely expose themselves, like our European distasteful species of Phytophagous *Timarcha*. Under these circumstances the intense black ground-colour and red spots of *B. apterus* must render it remarkably conspicuous, and it would be of great interest to ascertain, by a number of experiments on many insect-eaters, whether so pronounced an aposeme may indicate hardness alone or hardness combined with some other special protection.

The small size of the *Brenthidæ* renders it improbable

that hardness alone can be sufficient protection to the mimicked species, such as the Bornean *Diurus fureillatus*, and we are led to suspect the existence of unpalatability. In the cabinet the specimens seem to be markedly cryptic, but Mr. Shelford assures me that they are very commonly found on flowers, where their dull dark colours would be most conspicuous. Above all things experiments with insect-eating animals are greatly needed to throw light on this most puzzling and exceptional occurrence, viz. the existence of large numbers of models for mimicry among Rhynchophora with an apparent, and certainly in many cases an actual cryptic appearance.

32. Common Warning Colours in South African Hymenoptera and the Mimicry of them by Insects of other Orders. (G. A. K. M.)

A. *Group with Black Bodies and Dark Blue Wings, chiefly Fossores.*

Hymenoptera

Apidæ (Pl. XXI)	Xylocopa hottentota (fig. 18); X. carinata (fig. 19).
Eumenidæ (Pl. XXI)	Eumenes tinctor (figs. 14, 15); E. dyschera (figs. 16, 17).
Sphegidæ (Pl. XXI)	Sphex bohemani (figs. 1, 2); S. cyaniventris (fig. 3). S. pelopeiformis (figs. 4, 5); S. xanthocerus (fig. 6). S. umbrosus (fig. 7); Sceliphron chalybæum (fig. 8). Tachytes natalensis (figs. 9, 10); Ammophila ludovicus (figs. 11, 12). A. beniniensis (fig. 13).
Pompilidæ (Pl. XX)	Salius atropos (fig. 14); S. vindex (fig. 15). S. dedjax (fig. 16); S. regina (fig. 17); S. obscurus (fig. 18). Pompilus sepulchralis (fig. 19); P. frustratus (fig. 20).
Scoliadæ (Pl. XX)	Elis lachesis (fig. 3); E. fasciatipennis (figs. 4, 5). Scolia alaris (figs. 6, 7, 8); S. fraterna (figs. 9, 10). S. cyanea (figs. 11, 12); S. affinis (fig. 13).
Tiphiidæ	Tiphia rugosa (Pl. XX, fig. 2).
Mutillidæ	Mutilla atropos (Pl. XX, fig. 1).